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Heavy-metal uptake by crops from polluted river sediments covered by non-polluted topsoil

II. Cd-uptake by maize in relation to root development

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Abstract

Cadmium uptake by maize from polluted river sediments covered with a clean top layer of variable thickness is discussed in relation to root distribution. Two pathways for uptake are distinguished: roots penetrating the contaminated layer or contaminants moving into the root zone. Relative Cd uptake proved to be roughly proportional to the fraction of total root length found in the contaminated layer. A deeper water table induced a deeper root development and more Cd uptake for a given thickness of clean topsoil. A model based on exponential decrease of root length density with depth is acceptable as first approximation only. Little or no evidence was found for contaminants moving into the root zone during the ten years of the experiment.

Introduction

When a soil is too contaminated to grow crops which comply with public health standards, the simplest and cheapest solution often seems to cover such soil with less contaminated topsoil. This way of "covering up" problems obviously does not provide a real solution, but if the pollutants do not move into the root zone and the roots do not enter into the polluted soil, it may lead to a situation where all legal requirements are met without direct health risks.

The topsoil depth required to meet standards of permissible crop contamination is important in the economic evaluation of this option. Model calculations to evaluate a wide range of situations should be based on knowledge of underlying processes. The simplest assumption about root distribution is to expect an exponential decrease of root length density with depth (Gerwitz and Page, 1974). Considerable deviations from such a pattern can occur, however, and actual root length density in the subsoil can be both higher and lower than expected from such a description.

Two pathways exist for contamination of the crop: direct uptake from the contaminated zone and indirect uptake, after transport of contaminants into the root zone. The relative importance of both pathways depends on the nature of the contamination, on soil conditions in the topsoil, in the contaminated subsoil and their interface, on the crop, and on the water balance of the soil. Here we will evaluate the contribution of both pathways to Cd uptake by maize from a polluted river sediment (harbour sludge), covered by various depths of an uncontaminated clay soil. Compared to a range of other crops, maize requires a rather thick layer of clean topsoil in this situation (Van Driel et al., 1995). In the tenth and last year of a long-term experiment soil samples were taken to evaluate upward transport of metals and root distribution was measured to check the possible significance of the direct pathway.

For the root observations the following specific questions were formulated:

1. Is maize root distribution influenced by the depth at which the transition of topsoil to harbour sludge